Nasal Harmony in Optimal Domains Theory[1]

This paper proposes an analysis of nasal harmony within the framework of Optimal Domains Theory (ODT), and demonstrates that transparency and opacity derive from principled constraints that limit the realization of Nasal on potential anchors. The analysis differs fundamentally from the autosegmental analysis in two respects: it does not treat harmony as feature spreading, and it does not use feature specification or feature geometry to distinguish transparent and opaque segments from segments that undergo harmony. The ODT approach can account for the presence of inherently nasal segments that are transparent to harmony, as demonstrated in our analysis of Terena, unlike the autosegmental analysis, which incorrectly predicts that nasal segments will always trigger or be opaque. We also discuss why obstruents are typically opaque to nasal harmony, in light of the notion of contrast and the need to preserve contrast in harmony systems. The ODT analysis is based on the notion of the feature domain and the articulation of constraints which govern both the size and the composition of the feature domain, in this case for the feature [Nasal].

1 Optimal Domains Theory

The primary idea of ODT, as outlined in Cole & Kisseberth 1994a, is that phonological features are parsed in *domains*. F-domains are abstract structures, explicitly encoded in phonological representation, with the same status as the structural domains of foot and syllable. F-domains may be aligned with other feature domains or with prosodic domains such as Prosodic Word, Foot or Syllable.[2] Harmony occurs when an F-domain is subject to wide-scope alignment, extending beyond the segment that sponsors [F] in underlying representation. However, a wide F-domain is not a sufficient condition for harmony; it is also necessary that the harmony feature be be realized on anchors in the F-domain.

The ODT analysis makes no critical assumptions about the underlying specification or underspecification of elements in the F-domain of the harmony feature. If a segment in an F-domain is not inherently specified for the feature F, then F may be inserted on that element (1a). If the segment is specified for F, then nothing more is required (1b). If the segment is specified for some feature G which cannot combine with F, then it is possible that G will remain unparsed in order for F to be inserted on the segment (1c), or that F will fail to be inserted on the segment (1d). The result is that both underspecified and specified segments can undergo harmony (i.e., a single harmony system can be both feature-changing and feature-filling).

1. Parsing F-domains

a. ...X... $\longrightarrow$ (...X_F...)
b. ...X_F... $\longrightarrow$ (...X_F...)
c. ...X_G... $\longrightarrow$ (...$X_{<G>,F}$...)
d. ...X_G... $\longrightarrow$ (...X_G...)

There are three basic constraints of Universal Grammar that govern the alignment of F-domains. Basic Alignment (2) states that an F-domain will be co-extensive with

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[2] ODT adopts the basic architecture of Optimality Theory (Prince and Smolensky 1993). In particular, alignment of feature domains is handled through Alignment Theory, as put forth in McCarthy and Prince 1993.

the segment that sponsors it in underlying representation. The Wide-Scope Alignment constraints (3) derive the broad domains that give rise to harmony, and align an F-domain with a morphological or prosodic category. The Expression constraint (4) states that the feature [F] must be realized in the phonetic expression of every element in an F-domain.

2. Basic Alignment

BA-left: Align(F-domain, L; Sponsor, L)
BA-right: Align(F-domain, R; Sponsor, R)

3. Wide-Scope Alignment

WSA-left: Align(F-domain,L; P-Cat/M-Cat,L)
WSA-right: Align(F-domain,R; P-Cat/M-Cat,R)

4. Expression: The phonetic feature [*F*] must be expressed on every element in an F-domain.

In addition to these constraints, constraints on feature distribution play an important role in accounting for patterns of opacity and transparency in harmony systems. For instance, grounding constraints (as described in Archangeli and Pulleyblank 1994) limit feature distribution by imposing negative or positive constraints on feature combinations.[3]In the ODT analysis of harmony, opacity and transparency arise when grounding constraints dominate wide scope alignment, prohibiting certain segments from realizing the harmony feature. In general, the three types of behavior that segments may exhibit in harmony systems—participancy, transparency, and opacity—are derived through the interaction of the alignment and Expression constraints with grounding constraints, as summarized in (5).

5. Constraint rankings

Harmony:	WSA >> BA
	Expression >> *Insert [F]
Transparency:	grounding constraint >> Expression
	WSA >> Expression
Opacity:	grounding constraint >> WSA
	Expression >> WSA

The tableau in (6) provides a schematic example of domain structure parsed for an underlying feature F, and demonstrates how harmony, transparency, and opacity arise from domain parsing. The constraints involved include the WSA, BA and Expression constraints for the feature [F], as well as the grounding constraint *[F,G] and the faithfulness constraint *Insert[F] (from the Fill family of constraints). (6a) has a narrow F-domain, and therefore no harmony; (6b) has a wide F-domain, and full harmony; (6c) has a wide F-domain, but the medial vowel is transparent; and in (6d), the medial V is opaque.

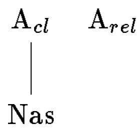
[3]We assume that UG contains a limited set of grounding constraints, all of which should reflect physical constraints on the acoustic or articulatory manifestation of features, and which should also serve as the basis of universal markedness statements. At present, phonetically-motivated, universal constraints such as *[ATR, Low], *[Round, Low], and *[Nasal, Obstruent] are sufficient to account for the patterns of transparency and opacity found in the large set of harmony systems we have examined, and language-specific constraints on feature distribution have not been required. For a discussion of universal prosodic conditions on feature distribution in harmony systems, see Cole and Kisseberth 1994b.

6. A schematic example of parsed F-domains

input:	$V_F...V_G...V$	*[F,G]	WSA-rt	Express	*Insert	BA-rt
a.	$(V_F)...V_G...V$		*			
b.	$(V_F...V_{F,G}...V_F)$	*			**	*
c.	$(V_F...V_G...V_F)$			*	*	*
d.	$(V_F...)V_G...V$		*			*

The next two sections present explicit ODT analyses of nasal harmony in Terena and Orejon, where both transparency and opacity are encountered. These analyses reflect two assumptions we make concerning the status of nasal segments. We attribute to prenasalized stops, represented below as [nd, mb], etc., an aperture structure representation that specifies distinct closure and release nodes, in which the Nasal feature is linked only to the closure (Steriade 1993), as shown in (7). In addition, following Rice 1993, a prenasalized stop is interpreted (perhaps not exclusively) as the phonetic expression of the phonological structure [Nasal, Obstruent, Stop].

7. Aperture structure of prenasal stops



2 Terena Nasal Harmony

Nasal harmony in Terena (Bendor-Samuel 1960) marks 1st person forms (nouns and verbs), through the nasalization of the stem, starting at the left edge and extending up until the first stop or fricative.[4] The stop or fricative at the boundary of nasal and oral domains is realized as prenasalized. The set of consonants found in non-nasal words is shown in (8), and represents the underlying inventory. Examples of nasal harmony are shown in (9); notice in particular the last three forms, in which nasal harmony passes through an underlying nasal stop.

8. Terena consonant inventory

p	t		k	
	s	š	h hy	
	l	r		?
m	n			
	y		w	

9. Terena examples

3sg. subject	*1sg. subject*	
piho	mbiho	'went'
otopiko	õndopiko	'chopped'
simoa	nzimoa	'came'
iwatako	ĩw̃ãndako	'sat'
arunoe	ãr̃ũnõẽ	'girl'
yono	ỹõnõ	'walked'
omo	õmõ	'carried'

[4]Autosegmental analyses of Terena appear in van der Hulst and Smith 1982, and Trigo 1988. See also Steriade 1993.

The interesting features of the Terena system are the transparent nasal stops and the opaque obstruents that undergo a partial nasalization, deriving prenasalized stops. In the ODT analysis of Terena, harmony results from two alignment constraints. WSA-left (10a) requires a domain for the feature Nasal at the left edge of every stem that bears the morphological feature *1sg*. This constraint, highly-ranked, is sufficient to introduce the Nasal feature on 1sg. words. The ODT analysis does not require the presence of a floating morphemic Nasal feature. The second alignment constraint is WSA-right (10b), which requires the right edge of a nasal domain at the right edge of every 1sg. word. WSA-left is undominated, since every 1sg. word has a nasal domain at its left edge, but WSA-right must be dominated, since the presence of an opaque segment stops the full rightward extension of the nasal domain.

10. Nasal domain alignment

a. Wide Scope Alignment-left: Align(1sg, L; N-domain, L)

b. Wide Scope Alignment-right: Align(1sg, R; N-domain, R)

All sonorants, including vowels, nasal stops, glides and /r/, occur with nasalization in a Nasal domain. This is accomplished by the Express [Nasal] constraint. The transparency of nasal stops in this system requires no special stipulation. Expression requires the Nasal feature to be realized on every element in a Nasal domain, and it is satisfied by the underlying Nasal feature of a nasal stop. It is evident that ODT avoids the false prediction of the autosegmental analysis, that an underlying Nasal feature will block nasal harmony. The following tableau illustrates evaluation of underlying /omo/ ‘carried, 1sg.’. The optimal candidate (11e) satisfies both of the WSA constraints and Expression, with two violations of *Insert[Nasal] incurred by the nasalization of each of the vowels in the harmony domain.[5]

11. Evaluation: transparent nasal stop in Terena[6]

input:	omo (1sg)	WSA-lf	Express	WSA-rt	*Insert[N]
a.	omo	*!		*	
b.	(omo)		*!*(o,o)		*
c.	(õ)mo			*! mo	*
d.	(õm)o			*! o	*
#e.	(õmõ)				**

The blocking behavior of obstruents, as in an example like *õndopiko* (cf. (12)), derives from the combined effects of the Express [Nasal] constraint and the faithfulness constraint Parse [Obstruent]. Expression requires Nasal to be realized uniformly throughout a Nasal domain. An obstruent in a Nasal domain can realize the feature Nasal in two ways: by combining [Nasal, Obstruent] and surfacing as a prenasalized stop (12b), or by losing the Obstruent feature and surfacing as a full nasal stop (12c). But neither of these results is optimal in Terena. The prenasalized stop does not fully satisfy Expression, since nasality

[5]In the interest of space, WSA-lf and *Insert[N] will not be included in the remaining tableaux. WSA-lf is undominated, and therefore always satisfied by the optimal form. *Insert[N] is not crucial in identifying the optimal candidate in the evaluation of harmony forms considered here, since it is dominated by WSA-rt. *Insert[N] plays a crucial role in the grammar only in the very general sense of prohibiting the free insertion of Nasal in words that do not undergo the *1sg.* nasal harmony.

[6]Vertical lines separating constraints indicate constraint ranking. Constraints that are not separated are not critically ranked with respect to each other. The pound sign # marks the optimal form.

is not uniformly realized throughout the duration of the stop. The full nasal stop satisfies Expression, but at the expense of a Parse [Obstruent] violation, since Nasal and Obstruent cannot both be linked to a single aperture position. If both Express [Nasal] and Parse [Obstruent] are ranked above WSA-right, then an obstruent will block harmony. Evaluation of candidates for underlying /otopiko/ with 1sg. inflection is shown below.[7]

12. Evaluation: medial opacity in Terena

input:	oto...(1sg)	Express	Parse[Obst]	WSA-rt	*[N,Obst]
a.	(õtõ...)	*!(t)			
b.	(õndõ...)	*!(d)			*
c.	(õnõ...)		*!		
#d.	(õn)do...			*($d_r o$)[8]	*
e.	(õ)to...			*!($t_{c,r}$o)	

Although the the candidates in (12a-c) all parse the maximal Nasal domain, satisfying both WSA-left and WSA-right, none of them is optimal, due to the dilemma posed by the presence of an underlying obstruent in the middle of the domain. The form in (12d) is the winner, indicating that both Express [Nasal] and Parse [Obstruent] are ranked above WSA-right. (12d) is also is superior to (12e) in its right alignment, if alignment is calculated in terms of aperture positions, and not in terms of entire segments, and if WSA-right dominates *[Nasal, Obstruent].[9]

The next tableau illustrates the evaluation of underlying /piho/ 'went, 1sg.', and is completely parallel to the tableau above, except that this time the opaque obstruent is the first element in the domain. This example shows that WSA-left is undominated in the grammar of Terena, since the Nasal domain does not skip an initial obstruent, even if doing so yields a much larger, and better right-aligned Nasal domain, as in the form in (13a).

13. Evaluation: initial opacity in Terena

	input: piho(1sg.)	WSA -lf	Expr	Parse [Obstr]	WSA -lf	*[N, Obstr]
a.	p(ĩhõ)	*!p				
b.	(mbĩhõ)		*!(b_r)			*
c.	(pĩhõ)		*!($p_{c,r}$)			
d.	(mĩhõ)			*!		
#e.	(m)biho				*(b_r iho)	*
f.	()piho				*!($p_{c,r}$ iho)	

[7]We do not explicitly consider candidates in which underlying /t/ is realized as [nt], which can be excluded by an undominated constraint requiring uniform voicing throughout both phases of a stop. Similarly, a voiceless nasal is excluded from consideration due to the undominated grounding constraint Nasal → Voice.

[8]Subscripts denote the aperture positions of closure (c) and release (r).

[9]It's possible that there are additional factors that motivate the derivation of a prenasalized stop at the right edge of a nasal domain. For instance, aligning the nasal transition (open velum to closed) and the aperature transition (closure to release) may increase their perceptibility, since it increases the degree of contrast between the material on either side of the combined transition. A second factor may be related to the relatively marked status of nasalized vowels in contrast with nasal stops. A fully constricted aperture seems to be the best host for nasality, in which case the alignment of a Nasal domain with closure can be seen as a way to 'strengthen' the Nasal domain, by providing it with a more prominent peripheral, or 'head' element.

To summarize, the constraint hierarchy necessary to derive the patterns of transparency and opacity found in Terena includes the following rankings:

14. Constraint ranking for Terena

deriving opaque obstruents:	Express[N], Parse[Obst] >> WSA-rt
deriving prenasalized stops:	WSA-rt >> *[N,Obst]
deriving participating sonorants:	Align-rt, Express[N] >> *Insert[N]

3 Orejon Nasal Harmony

Nasal harmony is manifest in Orejon in the distribution of oral and nasal vowels. While Nasal is freely contrastive on consonants in underlying forms, it is contrastive for vowels only in the stem-initial syllable, where it triggers a rightward harmony, extending across spans of vowels, and the weak glides /h, j/.[10] Examples of nasal harmony are shown in (15), where it is seen that harmony is blocked by voiced and voiceless consonants. Note that the nasalized vowel can be preceded by an initial voiceless consonant, as in (15b).

15. Orejon nasal harmony

a.	ãĩco	'espiritu malo'
	ãgada	'músculo'
	ãĩse	'lo que fue comido'
	ũĩdo	'lugar donde se echa algo o se cava'
	ãbI	'corazón'
	ẽõyi	'amarrar, agarrar con los dedos'
	ãjĩtu	'bastón'
	ãhĩja	'risa'
b.	pĩbI	'hanchaco'
	pĨcatu	'palo seco, podrido'
	cãde	(cãde mano oiyi) 'preferir'
	sẽjẽ	'especie de pájaro'
	sõjõbI	'pupo, ombligo'
	sĨjẽ	(sĨjẽ cã ñi jã) 'naranjo podrido'

In stem-internal position, nasal vowels occur in only two environments: in a nasal harmony domain that is triggered by a nasal vowel in the initial syllable, and immediately following a nasal stop.[11] Only the contrastive vowel nasalization, on the first stem syllable, triggers harmony. The nasalization originating on a nasal stop extends only as far as the following vowel; it does not systematically extend through a following /j/, as shown by the examples in (16). In contrast, nasalization triggered by a vowel *obligatorily* extends

[10] The apparent transparency of laryngeal segments in nasal harmony systems is discussed in Piggott 1992. The velar glide /j/ (adopting the transcription of Velie and Velie 1981) has a weak supralaryngeal articulation (equivalent to the velar fricative of Castillian Spanish), and is therefore not predicted to exhibit laryngeal transparency. Trigo 1988 discusses the behavior of velars in a variety of phonological processes, and argues that velars often behave as weak, placeless glides. Sufficient for the analysis pursued below is that the oral airflow required for the velar and laryngeal glides is not compromised by simultaneous nasalization. Thus, we speculate that the velar and laryngeal glides are in fact not transparent, but undergo nasalization in nasal harmony domains. Unfortunately, no details about the phonetic properties of these sounds is given in the available references on Orejon.

[11] The nasalization of vowels following nasal stops is described in Velie 1975, but is not marked in the transcription of Velie and Velie 1981.

rightward through /j/ or /h/, as in *sẽjẽ* 'especie de pájaro', *tãjõse* 'enterrado', and the last two forms in (15).

16. No nasal harmony following nasal stops

nẽjada	'flor.'
nãji	'nieto'

There are no stems with an initial voiced consonant (/b,d,g/) followed by a nasalized vowel (*#D$\tilde{V}$). A nasalized vowel in the stem-initial syllable is always preceded by a nasal stop (#N$\tilde{V}$), a voiceless consonant (#T$\tilde{V}$), or no consonant at all (#$\tilde{V}$). Putting this observation together with the fact, noted above, that nasal stops are always followed by a nasal vowel suggests that in addition to the rightward harmony, there is a local assimilation of Nasal within a syllable. Specifically, the Nasal feature associated with a nasal stop spreads onto the following vowel, and the Nasal feature associated with a vowel in the stem-initial syllable spreads onto a preceding voiced consonant. This local assimilation has the effect of neutralizing the contrast between voiced and nasal stops before a nasalized vowel.[12] Voiceless consonants are not affected by the local assimilation of Nasal, as evidenced by the examples in (15b), where a nasal vowel follows an initial voiceless consonant.

17. Local Nasal assimilation

$$\begin{array}{lcl} D\tilde{V} & \longrightarrow & N\tilde{V} \\ N\tilde{V} & \longrightarrow & N\tilde{V} \\ DV & \longrightarrow & DV \\ NV & \longrightarrow & N\tilde{V} \end{array}$$

The facts discussed so far are accounted for with the following set of constraints. The restricted distribution of nasal vowels is expressed through the Nasal Licensing constraint (18), which limits the feature Nasal on vowels to the initial syllable of a stem.[13] Local nasal assimilation derives from the Syllable/Nasal Alignment constraint in (19). Nasal Licensing is dominated by Syllable/Nasal Alignment (and Align-right, discussed below) with the result that Nasal can occur on vowels in stem-internal syllables only as a result of local nasal assimilation or nasal harmony.

18. Nasal Licensing: *[Nasal, Vocalic], unless in stem-initial syllable.

19. Syllable/Nasal Alignment: Align a Nasal domain with the left and right edges of a syllable.

When local nasal assimilation causes an underlying voiced obstruent to surface as a nasal stop (D$\tilde{V}$ → N$\tilde{V}$), it induces a violation of Parse [Obstruent]. Therefore, Syllable/Nasal Alignment must dominate Parse [Obstruent] in the constraint hierarchy, as demonstrated in the tableau in (20).

[12]The contrast between voiced and nasal stops (D:N) is maintained, however, in stem-internal position, where there are no contrastively nasal vowels.

[13]This can be subsumed under the more general notion of strong prosodic licensing, as discussed in Cole and Kisseberth 1994b. Specifically, a feature may be licensed only on prosodically strong positions, which are often identified with the initial and final units in a prosodic domain.

21. Evaluation: initial dṼ in Orejon

	UR: dṼ	Syll/N	Parse[Obst]
a.	d(Ṽ)	*!	
#b.	(nṼ)		*

The failure of voiceless stops to nasalize preceding a nasal vowel (e.g., (15b)) follows from the Nasal/Voice grounding condition (22), which must therefore dominate Syllable/Nasal Alignment, along with *Insert[Voice], as shown in the tableau in (23).

22. Nasal/Voice Grounding: If Nasal, then Voice.

23. Evaluation: initial tṼ in Orejon

	UR: tṼ	N/Vc	*Insert[V]	Syll/N
#a.	t(Ṽ)			*
b.	(n̥Ṽ)	*!		
c.	(nṼ)		*!	

In addition to these constraints, another alignment constraint is needed to account for rightward nasal harmony. The Align-right constraint (24) aligns a nasal domain to the right edge of a stem, but only in the case that the underlying sponsor of the Nasal feature is a vowel. Thus, harmony is triggered only by contrastively nasal vowels, i.e., those in the initial syllable.[14]

24. Weak Wide Scope Alignment (**WSA-rt**): Align(N-domain, R; Stem, R); applies only to Nasal domains in which the sponsor of Nasal is weak (Vocalic).

As noted above, rightward nasal harmony is blocked by voiced and voiceless stops and fricatives.[15] This is similar to the Terena pattern, except that in Orejon, the palatal glide /y/ also blocks harmony, as in *ẽõyi* 'amarrar, agarrar con los dedos' and *jẽyo* 'puente de un solo palo'. The complete consonant inventory is shown below.

[14]Orejon Nasal Harmony arguably falls in the class of prosodically conditioned harmony systems in which only prosodically weak elements trigger harmony, as discussed in Cole and Kisseberth 1994b. In this case, a vowel is determined to be a weak position for the feature Nasal, which accords with the relative markedness of nasal vowels in comparison with nasal consonants.

[15]There is no evidence available to indicate whether nasal stops are transparent or opaque to harmony in the environment (C)ṼNV. Vowels following a nasal stop are independently nasalized, although that nasalization is not marked in the transcription. Evidence would have to come in the form of a stem in which an internal nasal stop is followed by a transparent /j/ or /h/ in the next syllable, e.g., (C)ṼNVjV. If the final vowel is nasalized, then the nasalization must come from the initial syllable, since nasal stops do not generally spread nasalization rightward beyond the syllable (c.f., (16)). Unfortunately, a preliminary search reveals no such examples.

25. Orejon consonant inventory[16]

p	t		k	?
b	d		g	
	s		x	h
m	n	ñ		
		y		

In order to distinguish /y/ from the glides /h, j/ that do not block harmony, we analyze /y/ as an obstruent in this system. The class of segments we need to distinguish with the feature Obstruent contains just those segments which require a significant oral airflow, incompatible with simultaneous nasalization.[17]Under this interpretation, Orejon displays the same pattern of obstruent opacity as Terena, and can be analyzed in a parallel fashion. Specifically, opacity derives from the constraints Parse [Obsruent], *[Nasal, Obstruent], and Expres [Nasal], which all dominate WSA-right. The only difference in the opacity of Terena and Orejon is that in Terena the grounding constraint *[Nasal, Obstruent] is dominated by WSA-right, giving rise to nasal obstruents (i.e., prenasalized stops) at the boundary of oral and nasal domains. Nasal obstruents are not observed in Orejon, which is reflected in the grammar by making the grounding constraint *[Nasal, Obstruent] undominated. The tableau in (26) illustrates the evaluation of *ãbI* 'corazon', in which a medial obstruent blocks nasal harmony.

26. Evaluation: medial opacity in Orejon

input:	ãbI	Express	Parse[Obst]	*[N,Obst]	WSA-rt
a.	(ãbĨ)	*!(b)			
b.	(ãmĨ)		*!		
c.	(ãmbĨ)	*!(b)		*	
d.	(ãm)bI			*!	*($b_r I$)
#e.	(ã)bI				*(b_c, rI)

In addition to the absence vs. presence of prenasalized stops, there is one other important difference between Orejon and Terena. In Terena, the nasal domain is always strictly aligned at the left edge of the word, whereas in Orejon nasalization can originate on the first

[16]In citing examples, we adopt the non-standard transcription of Velie and Velie, in which the velar stop /k/ is represented by 'qu' before front vowels, and by 'c' elsewhere, and the velar glide /x/ is represented by 'j', as noted above. Also, Velie 1975 indicates the presence of preglottalized voiced stops, which are not transcribed in Velie and Velie 1981.

[17]This analysis would be confirmed if phonetic study revealed a genuine phonetic difference between the opaque palatal glide in Orejon and the transparent palatal glide in Terena, such that opacity correlated with greater air turbulence or increased pressure behind the constriction site. However, we maintain that even in the absence of such a phonetic distinction, it is possible for two languages to define the cut-off point for obstruency differently in the phonological grammar, on the basis of the degree of oral airflow. As noted by Cohn 1993, on a continuum of constriction degrees (from stop to vowel), contrastive nasalization is possible only at the two ends, requiring either full closure or no constriction. Nasalization is not compatible with the airflow requirement of fricatives, necessary to distinguish them from their stop counterparts. The status of approximants, including primarily the glides, varies somewhat across languages. A glide will block harmony only if the threshold for nasalization is drawn at a constriction degree less than that of glides, which implies that fricatives and stops will also block. In the ODT approach, it is possible to couch the present analyis of obstruent opacity without an explicit use of the feature Obstruent, by reformulating the constraints pertaining to obstruents (i.e., alignment, grounding, and Expression) so they make direct reference to consriction type.

vowel, skipping an initial voiceless stop. This distinction follows from the different ranking of the leftward alignment constraints on nasal domains in the two languages. In Terena, the morphologically governed WSA-left constraint is undominated. In Orejon, leftward alignment of the Nasal domain is accomplished by the Syllable/Nasal Alignment constraint (which dominates and therefore renders inactive the leftward Basic Alignment constraint for Nasal domains), and Syllable/Nasal Alignment is dominated by the grounding constraint on Nasal/Voice and *Insert[Voice], as seen in (23), so that a voiceless consonant preceding a nasal vowel does not undergo nasalization. In short, leftward alignment of a nasal domain is undominated in Terena and dominated in Orejon. A complete tableau illustrating the evaluation of the Orejon example *sõjõbI* 'pupo, ombligo' (15b), with both initial transparency and medial opacity, is shown below.

27. Evaluation: transparency and opacity in Orejon

	input: sõjobI	Expr	N/ Vc	Syll/ Nas	Prs [Obstr]	*[N, *Obstr]	WSA -rt
a.	(s̃õjõbĨ)	*!(b)	!(s)				
b.	(s̃õjõmĨ)		!*(s)		*		
c.	s(õjõmĨ)			!(s)	*!		
d.	s(õjõm)bI			!(s)		*!	$*(b_r I)$
e.	s(õ)jobI			!(s)			$*!(job_{c,r}I)$
#f.	s(õjõ)bI			!(s)			$*(b_c, rI)$

The first candidate in this tableau has the widest nasal domain, but incurs a violation of Expression and the Nasal/Voice grounding constraint. The Expression violation is resolved in the candidates (b-d), which however incur violations of Parse [Obstruent] and *[Nasal, Obstruent]. The Nasal/Voice violation is resolved in (b-f) at the expense of a violation of the lower-ranked Syllable/Nasal Alignment. Only the candidates (e) and (f) satisfy the Parse [Obstruent] and *[Nasal, Obstruent] constraints, and between them (f) best satisfies the wide scope alignment of Align-right, emerging as the winner.

We end the discussion of Orejon by briefly considering the analysis of a form in which an initial voiced or nasal stop is followed by an underlying nasal vowel, e.g. DṼCV. If the second consonant is an obstruent, then it will block harmony and the form should surface as NṼCV, which is also derivable from an underlying NVCV via local nasal assimilation. Numerous examples of this sort exist, such as *mãso* 'punchana', which would undergo an evaluation parallel to the one in (26). If, however, the second consonant in DṼCV is a transparent /j/ or /h/, then the surface result should be NṼjṼ. Examples like this can also be found, such as *nĨjõ* 'esposa'. It may seem as though this surface form could derive from underlying /nijo/, with nasality originating on the nasal stop, however that analysis must be rejected given that nasality from a nasal stop does not systematically spread beyond the syllable, as noted above in (16). Under the present analysis, the surface form *nĨjõ* is unambiguously derived from /dĨjo/ by Syllable/Nasal Alignment, and the wide scope Align-right constraint.

4 Discussion

The analyses of nasal harmony presented here show that harmony results from the wide-scope alignment of feature domains. Feature domains can arise through the need to parse an underlying feature, as in Orejon, or through a morphologically-governed Alignment constraint that identifies a feature domain with a particular morphological category, as in Terena. In both analyses, the domain alignment constraints alleviate the need to posit a floating Nasal feature in the underlying form of stems or suffixes, as has been proposed in numerous autosegmental analyses of these and other nasal harmony systems. By avoiding the floating feature, we also avoid the problem of how to order the floating feature differently in the two languages examined here: strictly *before* the initial consonant in Terena, but *after* an initial voiceless consonant in Orejon (cf. Pulleyblank 1989).

The ODT analysis succeeds in accounting for opacity in nasal harmony while assuming a privative Nasal feature. There is no appeal to the ad-hoc specification of a [-Nasal] feature, or to special feature geometries for nasal and non-nasal segments, in accounting for the behavior of opaque segments. In both of the systems examined here, opacity is limited to obstruents, and is ultimately due to the high-ranking of the Express [Nasal] and Parse [Obstruent] constraints: if Nasal must be expressed on all elements in the harmony domain, and if obstruents cannot lose their Obstruent feature, then the only outcome is for obstruents to remain outside of the domain of nasalization.

The pattern of obstruent opacity seen in Orejon and Terena is seen in other nasal harmony systems as well, including Urhobo, Sundanese, Aguaruna, and Mixtec, which means that the ranking of Express [Nasal] and Parse [Obstruent] over Wide Scope Alignment is relatively unmarked. Given the tenet of Optimality Theory that universal constraints can be extrinsically ranked in individual grammars, cross-linguistic trends in constraint ranking must be accounted for by appealing to higher-order principles. One principle that seems to be at work in nasal harmony systems is identified here as the Principle of Contrast Preservation (PCP), which disallows the neutralization of contrast, particularly in the absence of strong contextual cues. The PCP may ultimately be responsible for why obstruents don't simply undergo nasal harmony, becoming full nasals and allowing further extension of the harmony domain. If nasal harmony could obliterate the distinction between obstruents and nasals, then it would lead to substantial loss of contrast, undermining the most fundamental purpose of phonological features. In languages with morphological nasal harmony like that of Terena or Mixtec, the neutralization could cause a massive collapse in distinctions between root morphemes. It seems to be a very general property of nasal harmony systems that they avoid non-contextual neutralization. Of course, neutralization does occur in phonological systems, and in fact we have an instance of neutralization in the obstruent nasalization in Orejon, where it is argued that a voiced obstruent becomes a nasal stop before a nasal vowel. But note that in this case neutralization is limited to a specific phonological context—the stem-initial syllable. The three-way distinction between voiced, voiceless and nasal stops in underlying forms is preserved in stem-internal positions.

The PCP may also play a role in explaining why voiceless obstruents, even more than voiced obstruents, fail to undergo nasal harmony. This pattern is accounted for in ODT through the undominated constraints on Nasal/Voice grounding and *Insert [Voice]. The *Insert constraint, like Parse, is a faithfulness constraint, that serves the Principle of Contrast Preservation. In order for voiceless obstruents to undergo nasalization, deriving a voiced nasal stop, *Insert [Voice] and Parse [Obstruent] must be dominated. Yet, if Parse [Obstruent] is dominated, then a voiced obstruent in the same system will also undergo nasalization, and there would be a total collapse of the underlying system of contrast: T, D and N would all surface as N in nasal harmony domains. This is the sort of wholesale neutralization that is avoided in long-distance nasal harmony systems.

As discussed above, obstruent opacity requires the high ranking of both Parse [Obstruent] and Express [Nasal]. When Express [Nasal] is dominated, obstruent transparency may result. There are systems, such as Desano (Kaye 1971) and Guaraní (Rivas 1974, Gregores and Suárez 1967) in which voiceless obstruents are transparent to harmony, providing evidence that the ranking of Express [Nasal] is subject to variation. This suggests the possibility of a system in which voiced obstruents are transparent as well, with undominated Parse [Obstruent] and dominated Express [Nasal], and yet this pattern is conspicuously absent in the nasal harmony systems discussed in the literature. We leave the resolution of this issue to future research, but suggest that the answer may again lie in the need to preserve a perceivable contrast between T, D and N, distinguishing (...ṼTṼ...), (...ṼDṼ...), and (...ṼNṼ...).

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